

Orthogonal Frequency Division Multiplexing Technique

¹Komal Harvani, ²Arjav Bavarva

¹M.E. Student, ²Assistant Professor

Electronics & Communication Department, RK University, Rajkot, India

¹komalharvani30@gmail.com, ²Arjav.bavarva@rk.ac.in

Abstract— over the past few years, there has been increasing emphasis on extending the services available on wired public telecommunications networks to mobile non wired telecommunications users. At present, for mobile network users only low-bit-rate of 100 to 150 kbps data services are available. However, demands for wireless broadband multimedia communication systems (WBMCS) are increasing. It is necessary to use high-bit-rate transmission of at least several MBPS for upcoming new technologies. If digital data is transmitted at the rate of several MBPS, the delay time of the delayed waves is greater than 1 symbol time. Using one of the probably solution for adaptive equalizing signal. There are practical difficulties in operating this equalization at several megabits per second with compact, low-cost hardware. To overcome such an issue and to Achieve WBMCS. Orthogonal frequency division Multiplexing (OFDM) Apply to parallel-data transmission scheme, which reduces the influence of multipath fading and makes complex equalizers unnecessary.

INDEX TERMS— OFDM, WBMCS, ORTHOGONAL, ADC

I. OFDM BASICS

Basic concept of using a large number of parallel narrow-band subcarriers instead of a single wide-band carrier to transport information OFDM is a multi-carrier transmission technique, which divides the available spectrum into many Subcarriers, each one being modulated by a low Data rate stream it uses serial to parallel conversation scheme as shown in figure

The employment of discrete Fourier transform to replace the banks of sinusoidal generator and the demodulation significantly reduces the implementation complexity of OFDM modems At Receiver Side

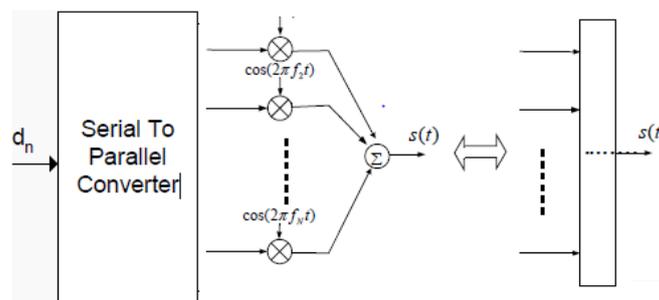


Figure 1 Serial to Parallel [2]

IV. OFDM System Design

Orthogonal frequency division multiplexing (OFDM) is a specialized frequency multiplexing (FDM) technique. It divides total available bandwidth into a number of orthogonal sub-carriers and simultaneously transfers signals on these sub-carriers with a low data rate, achieving a total data rate approaching ideal Nyquist data rate. Lower data rate on each sub-carrier means narrower bandwidth, which brings several benefits to the data transmission, such as flat channel fading and simpler receiver design.

An idealized OFDM communication system model can be shown as Figure 1. [1] In the transmitter, the signal source, a serial binary sequence, is first de multiplexed into multiple parallel data streams, corresponding to the number of sub-carriers to use. Each produced stream is performed with constellation mapping, i.e. modulated with a certain modulation scheme (e.g. BPSK). Then an inverse FFT is applied to each set of mapped symbols to convert them into time-domain samples.

These samples are then converted into an analog signal and up-converted to the RF frequency. When the receiver senses the signal, the RF signal is first down-converted and fed through a low-pass filter to generate a baseband signal. An ADC samples this baseband signal and the samples are then provided to an forward FFT. The parallel outputs from the forward FFT are multiplexed into a serial stream, and the stream of binary digits is the recovered transmitted information.

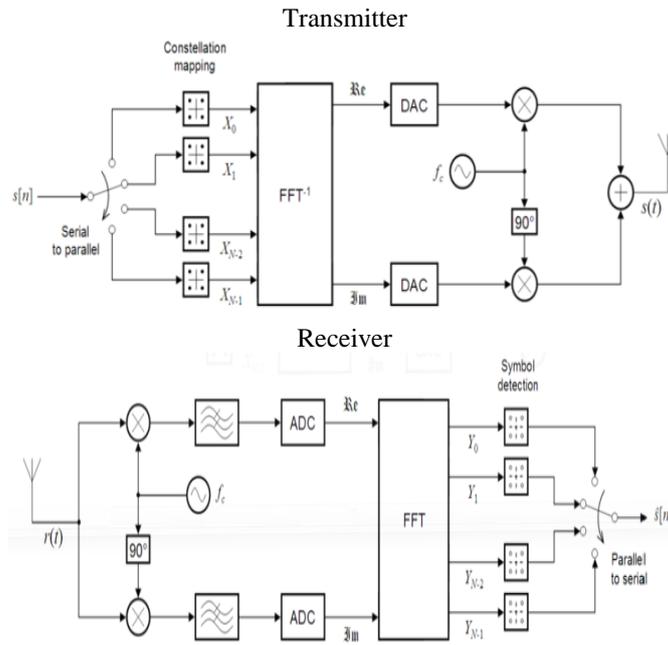


Figure 2^[1]

- IEEE Standard comparison

[1]IEEE 802.11a

- 54 Mbps
- For example, an 802.11a network, which broadcasts on the 5GHz frequency band, supports 12 simultaneous channels (in North American).
- Maximum data rate 12*54=648 Mbps.

[2]IEEE 802.11b

- 11Mbps
- For example, a standalone 802.11b network supports three non-overlapping channels (worldwide), each with a peak data rate of 11 Mbps.
- Maximum data rate 3*11=33 Mbps.

[3]IEEE 802.11g

- 54 Mbps
- For example, an 802.11g installation supports three channels, each with a peak rate of 54 Mbps.
- Maximum data rate 3*54=162 Mbps.

V TIMING OFFSET ESTIMATORS

The boundary of preamble and the frequency offset will be estimated by timing and frequency synchronization algorithms respectively and then the OFDM symbols inside the frame needs to be compensated for the frequency offset before carrying out demodulation. Using Following Methods

[1] Schmidl’s method

Two training symbols are placed at the beginning of each frame as preamble. Here, the sequence used to generate the training sequence should be chosen on basis of having a low peak-to-average power ratio so that there is little distortion in the transmitter amplifier

Type of Sequence	Peak-to-average power ratio
m-sequence	3.5568
Walsh code	62.0769
Gold sequence	75.7588

Table 1 PAPR Comparison

To detect the frame, the conjugate of a sample from the first half is multiplied by the corresponding sample from the second half, and then at the start of the frame, the products of each of these pairs of samples will have approximately the same phase and the magnitude of the sum will be peaked [4]. The *timing metric* of this estimator is given by following Equation

$$M(d) = \frac{|P(d)|^2}{(R(d))^2}$$

$$P(d) = \sum_{m=0}^{L-1} (r_{d+m}^* \cdot r_{d+m+1})$$

$$R(d) = \sum_{m=0}^{L-1} |r_{d+m+1}|^2$$

[2] Minn's method

Based on Schmidl & Cox method, Minn method modified the training sequence's pattern and timing metric's definition and designed the first training symbol having four parts with following patterns

$$S_M = [A, A, -A, -A]$$

where A represents samples of length $L = N/4$ generated by $N/4$ point IFFT of $4cN$ length modulated data of a PN sequence. The *timing metric* used in the evaluation of the technique is given by

$$P(d) = \sum_{k=0}^1 \sum_{m=0}^{L-1} r_{d+2Lk+m}^* \cdot r_{d+2Lk+m+L}$$

$$R(d) = \sum_{k=0}^1 \sum_{m=0}^{L-1} |r_{d+2Lk+m+L}|^2$$

Where r is the received signal, and d is a time index

Corresponding to the first sample in a sliding window of $4L$ samples

[3] Park's method

Minn's method reduces the timing metric plateau found in Schmidl's method but the MSE is still large particularly in ISI channels. This is resulted from the timing metric values around the correct timing point in Minn's method are almost the same. Park method proposed to increase the difference between the peak timing metric with respect to other metric values.

The proposed method entails modifying the training sequence's pattern and timing metric's definition to maximize the different pairs of product between them. The first training symbol having four parts with the following patterns:

$$S_P = [A, B, A^*, B^*]$$

Where A represents samples of length $L = N/4$ generated by IFFT of a PN sequence. B is designed to be symmetric with A. A^* and B^* are conjugate of A and B respectively. The *timing metric* is given by following equation.

$$P(d) = \sum_{k=0}^{N/2} r_{d-k} \cdot r_{d+k}$$

$$R(d) = \sum_{k=0}^{N/2} |r_{d+k}|^2$$

Where r is the received signal.

VI SIMULATION RESULTS

In this section, the proposed algorithm shows the estimation Performances for OFDM signals in P & R Parameter. The simulations were performed for the base-band model of signals. Data symbols are modulated with each carrier. The estimation performances with varying parameters of System Channels in shifted data are shown below. correct estimation probability in the graph indicates the proposed algorithm exactly estimating each parameter. From the result, P & R is recognized with 100% probability.

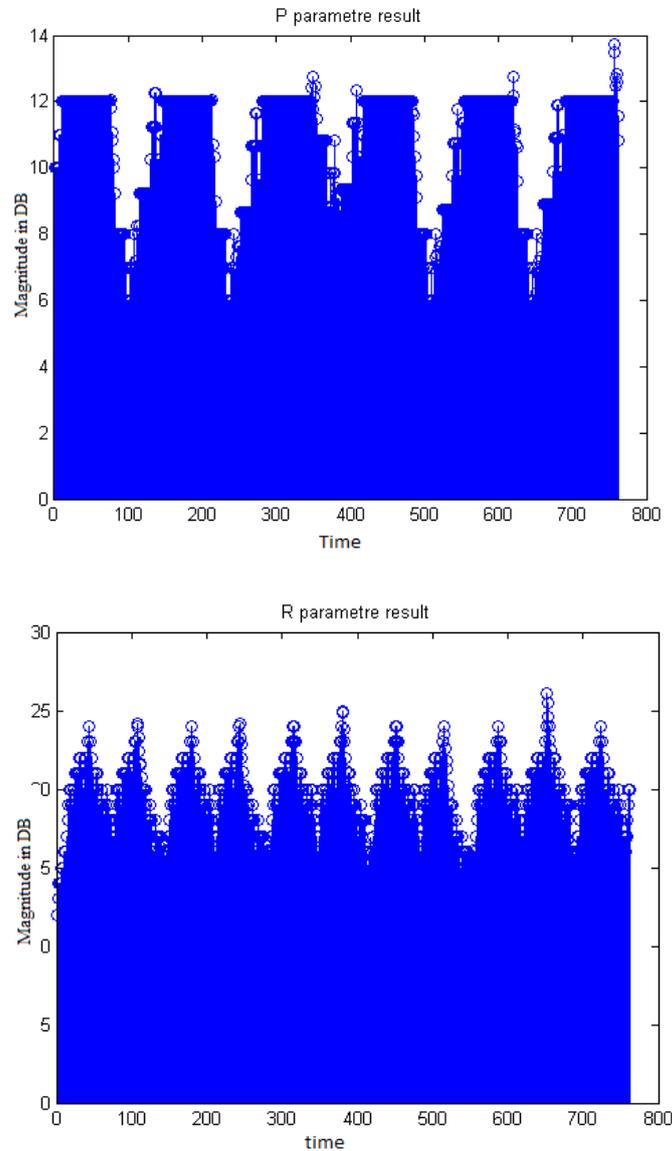


Figure 3

The reason is that many prefix symbols implemented in the frame featured a comparatively tough peak for the estimation, as shown in Figure.

Estimation performances for the other parameters are affected by the value of this Parameter. Here the Proposed algorithm seeks for the other parameters by using the Results identified in previous steps.

The performances added to both Parameters are shown in Figure.

VII WHY OFDM

OFDM possesses some inherent advantages for Wireless Communications

[1]Multi-path Delay Spread Tolerance

The increase in the symbol time of the OFDM symbol by N times (N being the number of sub-carriers), leads to a corresponding increase in the effectiveness of OFDM

[2]Effectiveness against Channel Distortion

In digital communication system. A typical example would be the twister-pair used in telephone lines. These transmission lines are used to handle voice calls and have a poor frequency response when it comes to high frequency transmission. In systems

that use single-carrier transmission, an equalizer might be required to mitigate the effect of channel distortion. In OFDM systems on the other hand, since the bandwidth of each sub-carrier is very small, the amplitude response over this narrow bandwidth will be basically flat (of course, one can safely assume that the phase response will be linear over this narrow bandwidth). Even in the case of extreme amplitude distortion, an equalizer of very simple structure will be enough to correct the distortion in each sub-carrier.

[3] Throughput Maximization & Latency minimization

The capacity of transmitting data packet per second will increase and time from transmitter to receiver for one packet will decrease. The symbol duration of the OFDM Symbol, it can be possible to change and according to Symbol duration latency and throughput will vary.

[4] Robustness against Impulse Noise.

Impulse noise is usually a burst of interference caused usually in channels such as the return path HFC (Hybrid-Fiber-Coaxial), twisted-pair and wireless channels affected by atmospheric phenomena such as lightning etc.

Symbol duration of an OFDM signal is much larger than that of the corresponding single-carrier system and thus, it is less likely that impulse noise might cause (even single) symbol errors. Thus, complicated error-control coding and interleaving schemes for handling burst-type errors are not really required for OFDM Systems simplifying the transceiver design.

[5] Frequency Diversity.

OFDM is the best place to employ Frequency Diversity. In fact, in a combination of OFDM and CDMA called the MC-CDMA transmission technique, frequency diversity is inherently present in the system.

VIII . THE PEAK POWER PROBLEM IN OFDM

One of the most serious problems with OFDM transmission is that, it exhibits a high peak-to-average ratio. In other words, there is a problem of extreme amplitude excursions of the transmitted signal. The OFDM signal is basically a sum of N complex random variables, each of which can be considered as a complex modulated signal at different frequencies. In some cases, all the signal components can add up in phase and produce a large output and in some cases, they may cancel each other producing zero output.

Thus the peak-to-average ratio (PAR) of the OFDM system is very large. The problem of Peak-To-Average Ratio is more serious in the transmitter. In order to avoid clipping of the transmitted waveform, the power-amplifier at the transmitter frontend must have a wide linear range to include the peaks in the transmitted waveform.

Building power amplifiers with such wide linear ranges is a costly affair. Further, this also results in high power consumption. The DAC's and the ADC's must also have a wide range to avoid clipping.

IX. Application

[1] DAB & HDTV

DAB is a digital Audio Broadcasting and HDTV is a High-definition Television digital technology offering considerable Advantages over today's FM radio & Television, both to entertainer and broadcasting.

[2] Wireless LAN

- IEEE 802.16 broadband wireless access system
A typical BWA network supports connection to many user premises within a radio coverage area. The IEEE 802.16 standard should provide the solution to access systems based on DSL, cable, and eventually fiber optics.

Table 2^[3] 802.16 bit rate and channel size

Channel Width (MHz)	Symbol Rate (Msym/s)	QPSK bit rate (Mbps)	16-QAM bit rate (Mbps)	64-QAM bit rate (Mbps)
20	16	32	64	96
25	20	40	80	120
28	22.4	44.8	89.6	134.4

- IEEE 802.20 mobile broadband wireless access
This allows applications including, but not limited to, video, full graphical web browsing, e-mail, file uploading and downloading without size limitations (e.g., FTP), streaming video and streaming audio, IP multicast, telemetric, location based services, VPN connections, VoIP, instant messaging and on-line multiplayer gaming

Table 3 ^[3] 802.20 bit rate and channel size

<i>Parameter</i>	<i>Bandwidth</i>			
	<i>1.25 MHz</i>		<i>5 MHz</i>	
	<i>Downlink</i>	<i>Uplink</i>	<i>Downlink</i>	<i>Uplink</i>
<i>Peak User Data Rate</i>	<i>4.5 Mbps</i>	<i>2.25 Mbps</i>	<i>18 Mbps</i>	<i>9 Mbps</i>

X . CONCLUSION

Comprehensive literature in OFDM Application area is presented in this paper. Corresponding Synchronization results are also given for their performances evaluation. Further, a simple but efficient FFT-based frequency estimator is Available as shown in OFDM System Design section, using Gaussian channel and Multipath fading channel we can Vary Symbol time and using Symbol Time latency will minimize and throughput will increase. Among of three Park's, Minn's and Schmidl's methods Minn's method is better. As an overall performance for minn's method gives the best Result.

REFERENCES

- [1] Fan Wu and Mosa Ali Abu-Rgheff "Time and Frequency Synchronization Techniques for OFDM Systems operating in Gaussian and Fading Channels" Mobile Communications Network Research School of Computing, vol. 2 issue 1, pp. 52–55, April 2005
- [2] Orthogonal Frequency Division Multiplexing for Wireless Networks - ANÍBAL LUIS INTINI
- [3] OFDM For Wireless communication System - Ramjee Prasad
- [4] Seung Duk Choi, Jung Min Choi, and Jae Hong Lee, "An Initial Timing Offset Estimation Method for OFDM Systems in Rayleigh Fading Channel", 2006 IEEE